# SPECIES RICHNESS, SPATIAL DISTRIBUTIONS AND DENSITIES OF LARGE- AND MEDIUM-SIZED MAMMALS IN THE NORTHERN PERIPHERY OF BOUMBA-BEK NATIONAL PARK, SOUTHEASTERN CAMEROON

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CITATION:

BOBO, Kadiri Serge ...[et al]. SPECIES RICHNESS, SPATIAL DISTRIBUTIONS AND DENSITIES OF LARGE- AND MEDIUM-SIZED MAMMALS IN THE NORTHERN PERIPHERY OF BOUMBA-BEK NATIONAL PARK, SOUTHEASTERN CAMEROON. African study monographs. Supplementary issue 2014, 49: 91-114

ISSUE DATE:
2014-08

URL:
https://doi.org/10.14989/189626

# SPECIES RICHNESS, SPATIAL DISTRIBUTIONS AND DENSITIES OF LARGE- AND MEDIUM-SIZED MAMMALS IN THE NORTHERN PERIPHERY OF BOUMBA-BEK NATIONAL PARK, SOUTHEASTERN CAMEROON

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ABSTRACT This study provides basic data on the species richness, spatial distributions, and densities of large- and medium-sized mammals in two Community Hunting Zones (CHZs 13 and 14) located in the northern periphery of Boumba-Bek National Park, southeastern Cameroon. The survey was conducted along 126 2-km transects and 101 recce walkways between transects, over a total of 398 km. A total of 31 species, or groups of species, of large- and medium-sized mammals were observed. The highest encounter rates (ERs) were recorded for red duikers (8.74 signs/km), blue duiker (6.12), and brush-tailed porcupine (4.42). Relatively high ERs (0.5 or more) were observed for elephant, red river hog, tree pangolin, yellow-backed duiker, and gorilla. Human activities including hunting and snaring were widely observed in the study area. Spatial distribution analysis revealed that different species were affected differently by human activities. In CHZ 13, an area more populated by humans, populations of red duikers and red river hog, important game animals for the local people, appeared to have decreased. In contrast, duikers and red river hog remained in CHZ 14 at similar levels as in the neighboring national parks. These results suggest that areas neighboring the park can exist in different stages of animal deterioration; therefore, the situation should be examined carefully to elaborate an effective wildlife management model that contributes not only to the conservation of biodiversity but also to the sustainable use of bushmeat by local people.

Key Words: Bushmeat hunting; Boumba-Bek National Park; Community Hunting Zone; Large- and medium-sized mammals; Wildlife management.

## INTRODUCTION

Human populations of Central and West African tropical forests rely on bushmeat, as sources of both protein and income (Eves & Ruggiero, 2000; Bakarr et al., 2001). Wild animals also have economic value derived from tourism and sport hunting (Chardonnet, 1995). However, both ecologists (Fa et al., 2002; 2003) and local communities (Akumsi, 2003) recognize that the wildlife situation in the Congo Basin is presently in crisis.

As noted by Doumenge et al. (2001), Cameroonian forests are crucial to the conservation of African biodiversity. Nonetheless, high-biodiversity sites in Cameroon are threatened by increasing human population densities (Barnes & Lahm, 1997). Overharvesting is above all considered to be the key cause of forest wildlife decline (Bennet et al., 2007). Expansion of the timber industry has extended the logging road network and has allowed hunters to access inner forest areas (Oates, 1999). In addition, shotguns and steel wires are replacing traditional hunting tools, leading to a drastic increase in the amount of bushmeat in neighboring markets (Lahm, 1993; Bakarr et al., 2001; Nzooh Dongmo et al., 2002; Yasuoka, 2006). In addition, farmers are moving into newly available forest areas to grow crops, which leads to forest fragmentation (Parren & de Graaf, 1995; Oates, 1999).

The Cameroonian government policy has been directed towards participative management by reconciling the well being of local communities with biodiversity conservation (Endamana & Etoga, 2007). This approach has resulted in the creation of Community Hunting Zones (CHZs) around some protected areas in southeastern Cameroon to promote sustainable management of animal resources. However, to assure the long-term success of CHZs; i.e., to secure bushmeat as a resource and to make it available for future generations, sustainable management models must be built and tested in the area (Davies & Brown, 2007). This strategy can be achieved by implementing a bio-monitoring program for mammals and socio-economic monitoring of bushmeat off-takes (Halford et al., 2003).

The present study will contribute to this project by providing baseline data on species richness, spatial distribution, and densities of large- and medium-sized mammals and on human activities that have influenced these variables.

## STUDY AREA

The study was conducted in CHZs 13 and 14, located along the northern periphery of Boumba-Bek National Park in the East Region of Cameroon (02°09'–02°20'N, 15°35'–15°50'E; Fig. 1). The two CHZs share boundaries with Boumba-Bek National Park and Nki National Park to the South. The area is characterized by an equatorial rainforest climate. Annual rainfall is about 1500 mm, mean temperature is 24°C, and relative humidity ranges from 60 to 90% (Ekobo, 1995). The vegetation is a mixture of evergreen and semi-deciduous forests (Letouzey, 1985). Vegetation surveys have revealed the presence of

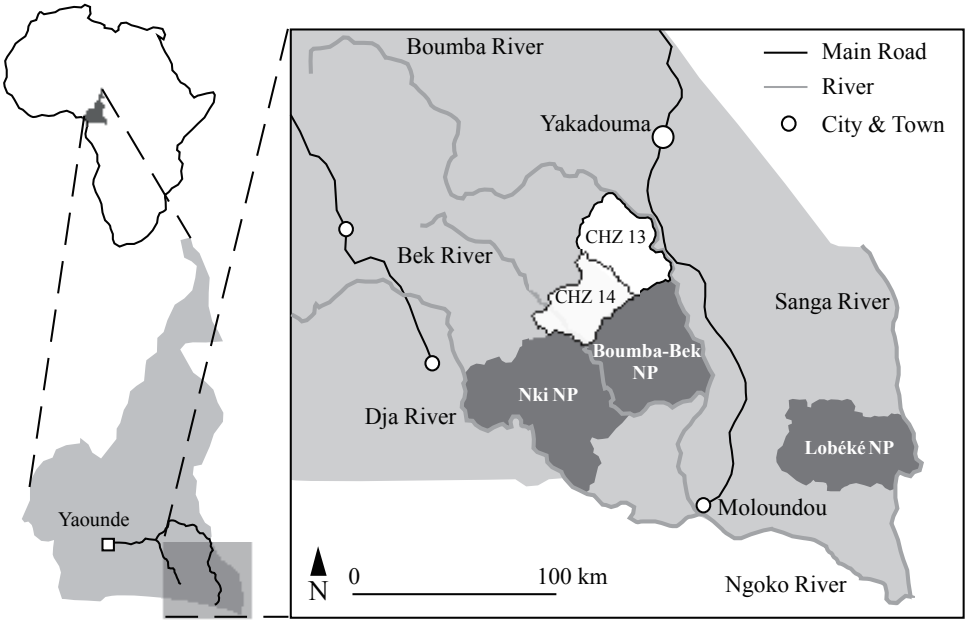


**Fig. 1.** Location of Community Hunting Zones (CHZ) 13 and 14.

831 species belonging to 111 families, and surveys on large mammals have confirmed the presence of 34 species, including 11 primates, 12 ungulates, and four carnivores (Ekobo, 1998; Makazi et al., 1998).

Along a secondary road that passes through CHZs 13 and 14 from northeast to southwest and branching off an unpaved highway between Yokadouma and Moloundou, five villages reside in each of CHZs 13 and 14. The villages in CHZ 13 contain a total of about 4,500 people, whereas CHZ 14 harbors only about 800, including the Baka Pygmies, the Konabembe, and other Bantu-speaking people (Halle, 2000; see also Fogue & Defo, 2006; Toda, 2014, this issue). As the areas of CHZs 13 and 14 are 1,130 and 877 $km^2$, respectively, population densities are estimated at 3.8 and 0.9 people/$km^2$. In the northern and northeastern parts of CHZ 13, working sawmills of logging companies have been in existence for at least 10 years, likely influencing the distribution of animals.

The main subsistence activities practiced by the local people are growing bananas, cassava, and cacao; gathering forest resources; and hunting animals. Blue duiker (*Cephalophus monticola*) and red duikers (*C. callipygus*, *C. leucogaster*, *C. dorsalis*, and *C. nigrifons*) represent the main harvested species (Zouya-Mimbang, 1998; Yasuoka, 2006). The primary hunting method is snaring with steel wire (WCS, 1996; Yasuoka, 2006). With the permission of the authorities, professional hunters practice trophy hunting between December and July. Species targeted are mainly bongo, elephant, buffalo, and sitatunga.

## METHODS

### I. Data Collection

The field survey was conducted in February and March 2012. We used a combination of line transect and recce (reconnaissance) walk surveys (White & Edwards, 2000) in accordance with the national norms for wildlife surveys in rainforests (MINFOF, 2006). CHZs 13 and 14 were divided into 131 quadrats of 4 × 4 $km^2$ each. In each quadrat, one 2-km-long transect was established. Two consecutive transects were joined by a recce walkway. Quadrats on the border were surveyed if its surface area was greater than or equal to 50% of the surface area of a full quadrat. We effectively covered 126 quadrats, for 126 transects (71 transects in CHZ 13 and 55 transects in CHZ 14) and 101 recce walkways (56 in CHZ 13 and 45 in CHZ 14), giving a total survey effort of 398 km (Fig. 2).

On both transects and recce walkways, we recorded direct observations of animals and humans and indirect signs such as tracks/footprints, dung, feedings, shouts, beddings, and carcasses. Along the transects, in cases of ungulate dung or primate beds, the perpendicular distances to the transect base line were recorded to create detection probability curves, which were used for density estimation.

Due to difficulties inherent to distinguishing their dung, footprints, and tracks on the forest ground, Peter's duiker (*Cephalophus callipygus*), bay duiker (*C. dorsalis*), black-fronted duiker (*C. nigrifons*) and white-bellied duiker (*C. leucogaster*) were grouped as red duikers (van Vliet et al., 2007).

### II. Data Analysis

To visualize the spatial distribution of each species, encounter rates (ERs) were calculated for each quadrat by dividing the number of signs by distance (km) walked, including both the 2-km transect and recce walkway within the quadrat. Subsequently, quadrats corresponding to a specific ER value were grouped into three or four ER classes. Lastly, we generated the spatial distribution for each species using the ArcGIS 10.0 software.

Densities of animals were calculated for species with relatively high abundances of dung or beds recorded along the transects; i.e., red duikers, blue duiker, elephant, gorilla, yellow-backed duiker, and chimpanzee. First, detection probability curves for dung/beds were produced using a Half-normal Cosine Adjustment Model in the Distance 6.0 software (Thomas et al., 2010). Dung density for each species was then estimated. We judged whether the estimation was acceptable using coefficients of variation (CV). CVs less than 30% were considered acceptable (Nzooh Dongmo, 2003; Bobo et al., 2006a; 2006b).

Densities of dung/beds were then converted into individual densities using defecation and dung decay rates, which were estimated by Koster & Hart (1988) in the Democratic Republic of Congo, and by Ekobo (1995) in Lobéké National Park, eastern Cameroon, and using bed production rates (Plumtre & Reynolds,

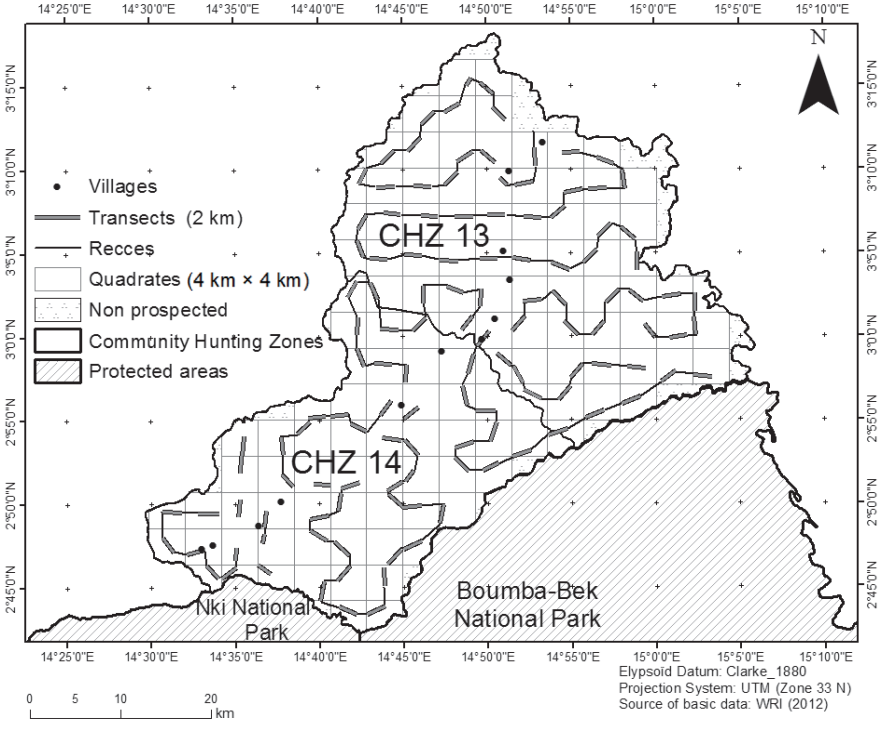


**Fig. 2.** The Sampling Design.

1996) and bed degradation rates (Tutin et al., 1995) obtained in the Lopé Forest Reserve in Gabon. Corresponding confidence intervals at a threshold of 95% were estimated for all density estimates of individuals. The formula used for conversion into individual density ($E$) was as follows:
where,

$$E = \frac{Y \times R}{D} \quad \text{or} \quad \frac{Y}{D \times R'}$$

$Y$: Dung/bed density;
$D$: Number of dung excreted or beds produced per day;
$R$: Dung/bed decay rhythm per day;
$R'$ (= $1/R$): Period (in days) of degradation of dung/beds.

## RESULTS

### I. Species Richness and Encounter Rate

Totals of 31 large- and medium-sized mammal species, or groups of species, and 9,922 signs thereof were recorded in CHZs 13 and 14, producing a rate of

**Table 1.** Number of signs and encounter rates (ER) of each species recorded on transects and reces in CHZs 13 and 14

| Species | Track and footprint | Dung | Feeding | Shout | Bedding | Direct observation | Carcass | Total | ER (signs/km) |
|---|---|---|---|---|---|---|---|---|---|
| Red duikers (*Cephalophus* spp.[1]) | 3,055 | 374 | 5 | | 16 | 20 | 1 | 3,471 | 8.74 |
| Blue duiker (*Cephalophus monticola*) | 2,186 | 213 | 2 | 1 | 13 | 12 | 1 | 2,428 | 6.12 |
| Brush-tailed porcupine (*Atherurus africanus*) | 1,715 | 9 | 14 | | 14 | 3 | | 1,755 | 4.42 |
| Elephant (*Loxodonta africana cyclotis*) | 228 | 313 | 17 | | | | 1 | 559 | 1.40 |
| Red river hog (*Potamochoerus porcus*) | 211 | 17 | 159 | | 2 | 2 | | 391 | 0.98 |
| Tree pangolin (*Phataginus tricuspis*) | 162 | 4 | 104 | | 1 | | | 271 | 0.68 |
| Yellow-backed duiker (*Cephalophus silvicultor*) | 180 | 42 | | | 1 | | | 223 | 0.56 |
| Gorilla (*Gorilla g. gorilla*) | 40 | 29 | 73 | 2 | 56 | | | 200 | 0.50 |
| Water chevrotain (*Hyemoschus aquaticus*) | 144 | 3 | | | | 1 | | 148 | 0.37 |
| Putty-nosed guenon (*Cercopithecus nictitans*) | | | | 123 | | 21 | | 144 | 0.37 |
| Chimpanzee (*Pan troglodytes*) | 8 | 4 | 8 | 5 | 36 | | | 61 | 0.15 |
| Sitatunga (*Tragelaphus spekei*) | 47 | 3 | 1 | | 1 | 1 | | 53 | 0.13 |
| Giant pangolin (*Smutsia gigantea*) | 21 | 1 | 22 | | 2 | | | 46 | 0.11 |
| Bate's pygmy antelope (*Neotragus batesi*) | 28 | 4 | | | | | | 32 | 0.08 |
| De Brazza's monkey (*Cercopithecus neglectus*) | | | | 20 | | 8 | | 28 | 0.07 |
| Grey-cheeked mangabey (*Lophocebus albigina*) | | | | 22 | | 4 | | 26 | 0.07 |
| Crowned monkey (*Cercopithecus pogonias*) | | | 1 | 18 | | 4 | | 23 | 0.06 |
| Bongo (*Tragelaphus euryceros*) | 9 | 3 | | | | | | 12 | 0.03 |
| Hedgehog (*Atelerix albiventris*) | 5 | | | | 5 | | | 10 | 0.03 |
| Marsh cane rat (*Thryonomys swinderianus*) | 2 | 2 | 5 | | | | | 8 | 0.02 |
| African civet (*Civettictis civetta*) | 6 | 1 | 1 | | | | | 8 | 0.02 |
| Long-snouted mongoose (*Herpestes naso*) | 7 | | | | | | | 7 | 0.02 |
| Buffalo (*Syncerus cafer nanus*) | 5 | 1 | | | | | | 6 | 0.02 |
| Leopard (*Panthera pardus*) | 2 | 1 | | | | | | 3 | 0.02 |
| Agile mangabey (*Cercocebus agilis*) | 1 | | 1 | 1 | | | | 3 | 0.01 |
| Giant pouched rat (*Cricetomys emini*) | 1 | | | | 1 | | | 2 | 0.01 |
| Western tree hyrax (*Dendrohyrax arboreus*) | | 2 | | | | | | 2 | 0.01 |
| Mona guenon (*Cercopithecus mona*) | | | | 1 | | | | 1 | 0.00 |
| Western guereza (*Colobus guereza*) | | | | 1 | | | | 1 | 0.00 |
| Total | 8,063 | 1,026 | 413 | 194 | 148 | 76 | 3 | 9,922 | 24.93 |

[1]Red duikers include Peter's duiker (*Cephalophus callipygus*), bay duiker (*C. dorsalis*), black-fronted duiker (*C. nigrifons*) and white-bellied duiker (*C. leucogaster*).

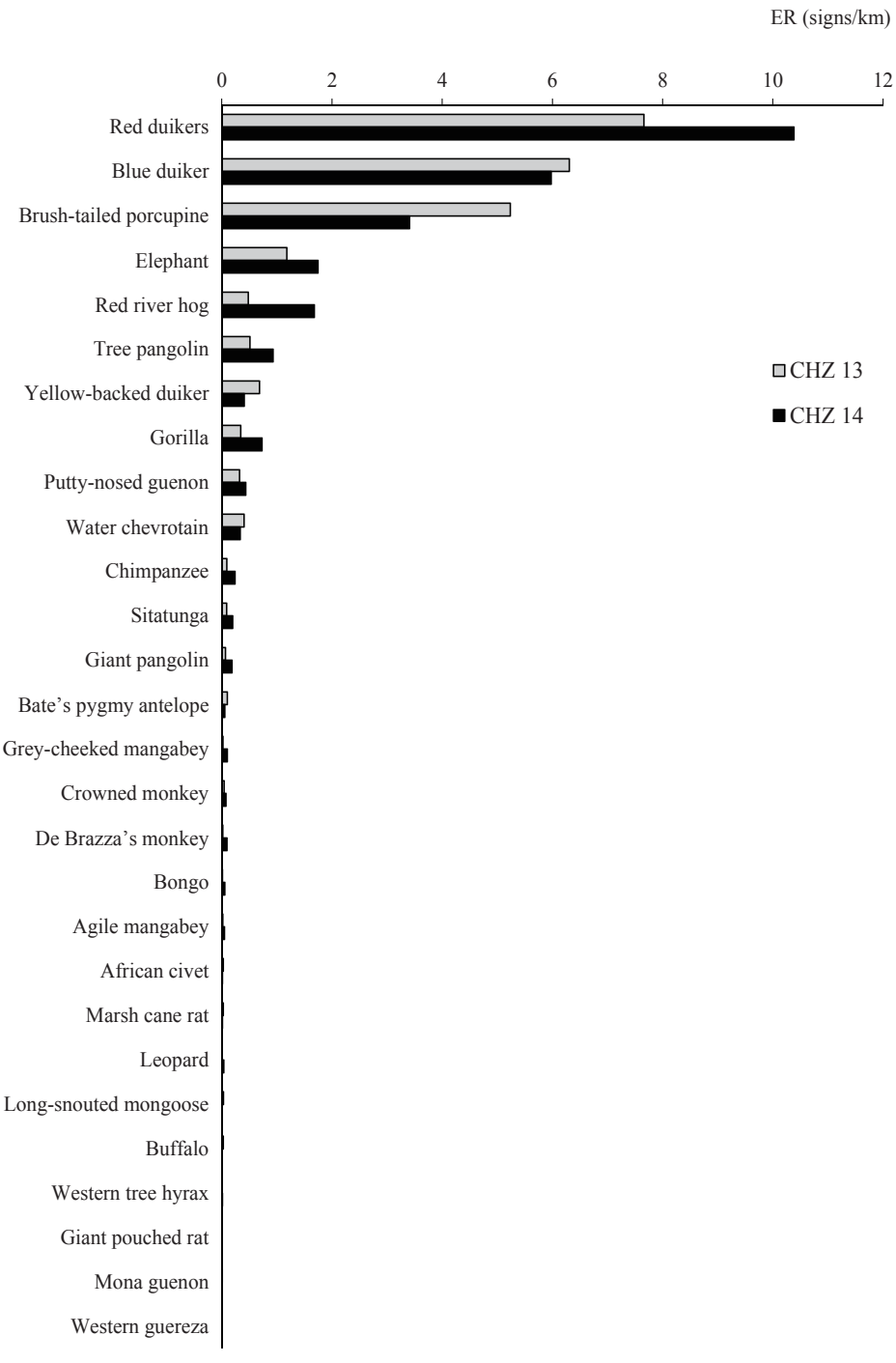


**Fig. 3.** Encounter rate (ER) of large and medium-sized mammals in CHZs 13 and 14.

24.9 signs/km (Table 1). The highest ERs were observed for red duikers (8.74 signs/km), blue duiker (6.12), and brush-tailed porcupine (4.42), accounting for 35.0%, 24.5%, and 17.7%, respectively, of the total signs encountered. Relatively higher ERs were observed for elephant (1.40), red river hog (0.98), tree pangolin (0.68), yellow-backed duiker (0.56) and gorilla (0.50). Although ERs for most species were higher in CHZ 14 than in CHZ 13, those for blue duiker, brush-tailed porcupine, yellow-backed duiker, and water chevrotain were higher in CHZ 13 (Fig. 3). In the following sections, spatial distributions are documented for species for which ERs were 0.1 or higher, although medium-sized monkeys were lumped together.

II. Spatial Distribution of Human Activity Signs

A total of 1,126 signs of human activities were recorded. Hunting tracks (55.1%), timber exploitation activities (24.6%), and snares, cartridges and gunshots heard (17.1%) were the main signs encountered. Other human activities were artisanal sawing, farmland extension, harvesting of NTFPs and fishing. The average ER was 2.84 signs/km for the entire survey area: 3.49 signs/km for CHZ 13 and 2.01 for CHZ 14. Signs of human activities were observed considerably more frequently in CHZ 13, although some quadrats in the highest ER class were found in the northern part of CHZ 14, which is typically accessed by people of the Gribe village. Fewer signs occurred in the southern part of CHZ 13 and most of CHZ 14 (Fig. 4). These results correspond well with densities of the human population and with the occurrence of roadways.

III. Spatial Distribution of Animal Signs

(1) Red duikers

A total of 3,471 signs of four species of red duikers were recorded. Tracks/footprints (88.0%) and dung piles (10.8%) were the major signs observed. The average ER was 8.74 signs/km for the entire survey area: 7.66 signs/km for CHZ 13 and 10.38 for CHZ 14. Quadrats in the highest and second highest ER classes were more frequently distributed in CHZ 14 (Fig 5). Higher ERs were also recorded in the eastern and western part of CHZ 13, where relatively fewer human activities were recorded (Figs. 4 & 5). The lower ER class were mainly found along the road and the southern part of CHZ 13.

(2) Blue duiker

Tracks/footprints (90.0%) were the most abundant of a total of 2,428 signs for blue duiker. We also detected 213 dung piles (8.8%). The average ER was 6.12 signs/km for the entire survey area, with 6.31 signs/km for CHZ 13 and 5.98 for CHZ 14. Unlike red duikers, most of the quadrats in higher ER classes were distributed from the northwestern part of CHZ 13 to the northern part of CHZ 14 (Fig. 6), even though relatively higher ERs of human activities were found in the northwestern part of CHZ 13 (Fig. 4).

(3) Brush-tailed porcupine

Tracks/footprints constituted the major signs of the brush-tailed porcupine, with 1,715 observations (97.7%). The average ER was 4.42 signs/km for the entire survey area: 5.23 signs/km for CHZ 13 and 3.40 for CHZ 14. Compared to the above-mentioned duikers, quadrats in the highest ER class were concentrated, especially in the western part of CHZ 13 (Fig. 7). In contrast, signs were absent in the southern parts of CHZ 14, even though fewer human activities were recorded.

(4) Elephant

Dung and tracks/footprints were the most abundant signs encountered for elephants, with 313 (56.0%) and 228 (31.8%) observations, respectively. The average ER was 1.40 signs/km for the entire survey area: 1.62 signs/km for CHZ 13 and 1.75 for CHZ 14. Most signs of elephants were recorded in the western part of CHZ 14 and in the northern and southeastern parts of CHZ 13 (Fig. 8). In general, we found fewer signs in densely populated areas of humans and along roadways, although some activities were observed in the northern part of CHZ 13.

(5) Red river hog

Of the 391 signs of red river hog encountered, tracks/footprints and food remnants were the most abundant, with 211 (54.0%) and 159 (40.7%) observations, respectively. Only 17 dungs were recorded, corresponding to 4.3% of the total observations. The average ER was 0.98 signs/km for the entire survey area, with 0.48 signs/km for CHZ 13 and 1.68 for CHZ 14. Almost all quadrats in higher ER classes were distributed in CHZ 14, especially in the western area (Fig. 9). The distribution of red river hog clearly corresponded to areas less populated by humans.

(6) Tree pangolin

We recorded a total of 271 signs of the tree pangolin, of which 162 (59.8%) were tracks/footprints, and 104 (38.4%) were food remnants. The average ER was 0.68 signs/km for the entire survey area, with 0.51 signs/km for CHZ 13 and 0.93 for CHZ 14. Most quadrats in higher ER classes were concentrated in the northern part of CHZ 14, whereas few signs were encountered in the southern parts of both CHZs (Fig. 10). This distribution was similar to that of brush-tailed porcupine.

(7) Yellow-backed duiker

A total of 223 signs of yellow-backed duiker were recorded. The main signs were tracks/footprints and dung piles, with 180 (80.1%) and 42 (18.8%) observations, respectively. The average ER was 0.56 signs/km for the entire survey area, with 0.68 for CHZ 13 and 0.41 for CHZ 14. Although quadrats of the highest ER class were found in the eastern part of CHZ 13, signs were scattered throughout both CHZs (Fig. 11). The ERs of CHZs 13 and 14 did not distinctly differ. This distribution was similar to that of elephants, which exhibited correspondence with areas less populated by humans.

(8) Gorilla

The most abundant signs encountered for the gorilla were food remnants, beddings, tracks/footprints, and dung, with 73 (36.5%), 56 (28.0%), 40 (20.0%), and 29 (14.5%) observations, respectively. The average ER was 1.22 signs/km for the entire survey area, with 0.34 signs/km for CHZ 13 and 0.73 for CHZ 14. Quadrats in higher ER classes were distributed from the northern part of CHZ 14 to the western part of CHZ 13. In contrast, quadrats in lower ER classes occurred from the eastern to southern part of CHZ 14 as well as the northern part of CHZ 13 (Fig. 12). A relationship between the occurrence of gorillas and the frequency of human activities was not clear.

(9) Water chevrotain

We recorded a total of 148 signs of water chevrotain, with tracks/footprints as the most abundant sign, with 144 (97.3%) observations. The average ER was 0.37 signs/km for the entire survey area, with 0.41 signs/km for CHZ 13 and 0.33 for CHZ 14. Quadrats containing signs of water chevrotain were distributed in the southern part of CHZ 14 and from the northern to eastern part of CHZ 13 (Fig. 13). Signs were absent from the center of the study area. Similar to the yellow-backed duiker, the distribution of water chevrotains resembled that of the elephant.

(10) Chimpanzee

A total of 61 signs of chimpanzees were recorded, with beddings representing 59.0% of the total observations. Some feeding signs, tracks/footprints, and dung were also recorded, with eight (13.1%), eight (13.1%), and four (6.6%) observations, respectively. The average ER was 0.15 signs/km for the entire survey area, with 0.09 signs/km for CHZ 13 and 0.24 for CHZ 14. Signs were scattered throughout CHZ 14 and in areas without roadways in CHZ 13 (Fig. 14). However, signs of chimpanzees were absent in many quadrats.

(11) Sitatunga

Of the 53 signs of the sitatunga encountered, tracks/footprints were the most abundant with 42 (79.3%) observations. The average ER was 0.13 signs/km for the entire survey area, with 0.09 for CHZ 13 and 0.20 for CHZ 14. Signs were absent in many quadrats. Most signs were found in CHZ 14, where human activities were less frequently observed (Fig. 15). The distribution of sitatunga was similar to that of the red river hog.

(12) Giant pangolin

A total of 46 signs of the giant pangolin were encountered. Food remnants and tracks/footprints were the most abundant signs encountered, with 22 (47.8%) and 21 (45.6%) observations, respectively. The average ER was 0.11 signs/km for the entire survey area, with 0.07 signs/km for CHZ 13 and 0.19 for CHZ 14. Signs were absent in many quadrats. Most signs were distributed in the northern part of CHZ 14 (Fig. 16).

(13) Medium-sized monkeys

Medium-sized monkeys encountered in the study area were putty-nosed guenon (144 signs), De Brazza's monkey (28), grey-cheeked mangabey (26), crowned monkey (23), agile mangabey (3), mona guenon (1), and western guereza (1). We recorded a total of 226 signs of these seven primates, among which shouts were most frequent with 184 signs (81.4%). A total of 37 groups were encountered, representing 16.4% of the total signs. The average ER was 0.57 signs/km for the entire survey area, with 0.44 signs/km for CHZ 13 and 0.76 for CHZ 14. Quadrats in higher ER classes were more frequently distributed in CHZ 14, and signs occurred very infrequently in the northern part of CHZ 13 (Fig. 17).

IV. Density

(1) Red duikers

A total of 64 dungs of red duikers were recorded along transects in CHZ 13, and 177 dungs were recorded in CHZ 14. Estimated densities were 215.9 dungs/$km^2$ (CV = 23.1%) in CHZ 13 and 663.9 (CV = 22.1%) in CHZ 14. Using the defecation rate (4.4/day) and the dung degradation rate (21 days) determined by Koster & Hart (1988), estimated densities were 2.3 individuals/ $km^2$ in CHZ 13 and 7.2 in CHZ 14 (Tables 2 & 3).

(2) Blue duiker

A total of 37 dungs of blue duiker were recorded along the transects in CHZ 13, and 118 dungs were recorded in CHZ 14. Estimated densities were 143.4 dungs/ $km^2$ (CV = 21.8%) in CHZ 13 and 431.3 (CV = 21.2%) in CHZ 14. Using the defecation rate (4.9/day) and the dung degradation rate (18 days) determined by Koster & Hart (1988) in dense forest of Democratic Republic of Congo (DRC), densities were estimated at 1.6 individuals/$km^2$ in CHZ 13 and 4.9 in CHZ 14 (Tables 2 & 3).

(3) Gorilla

A total of 11 groups of gorilla beds were recorded along the transects in CHZ 13, and 23 were recorded in CHZ 14. Densities were estimated at 9.65 groups of beds/$km^2$ (CV = 58.7%) in CHZ 13 and 24.5 (CV = 31.2%) in CHZ 14. We observed an average [±SE] of 2.00 ± 1.39 gorilla beds per group. Using the bed production rate (0.842/day) from Plumtre & Reynolds (1996) and the bed degradation rate (78 days) from Tutin et al. (1995) at the Lopé (Gabon), densities were estimated at 0.29 individuals/$km^2$ in CHZ 13 and 0.74 in CHZ 14 (Tables 2 & 3). Because the CV for the bed density estimation was far above 30%, we calculated the density for the entire study area. The estimated density was 30.4 groups of beds/$km^2$ (CV = 34.4%), producing a density of 0.46 individuals/$km^2$.

(4) Yellow-backed duiker

A total of eight dungs of yellow-backed duiker were recorded along the

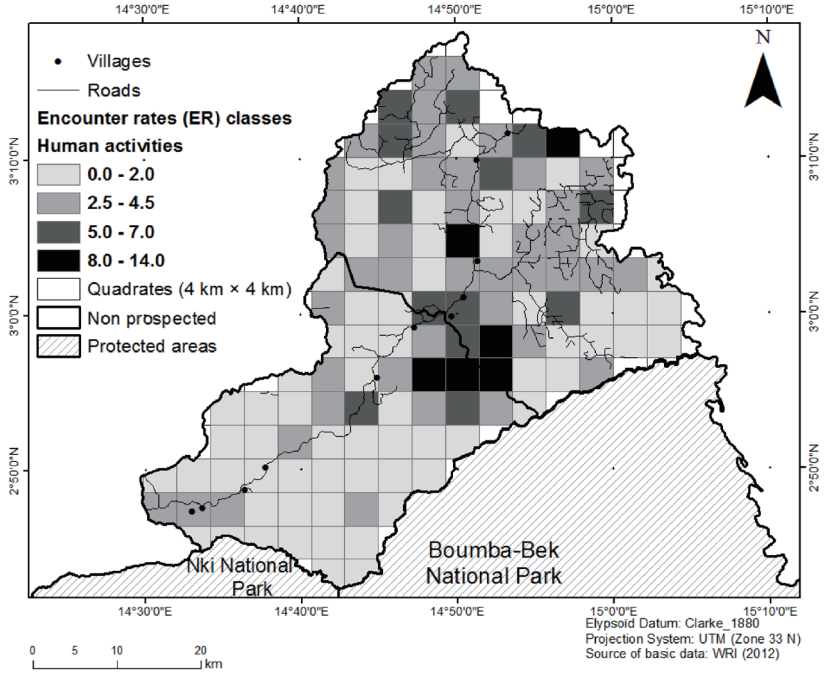


**Fig. 4.** Spatial distribution of signs of human activities.

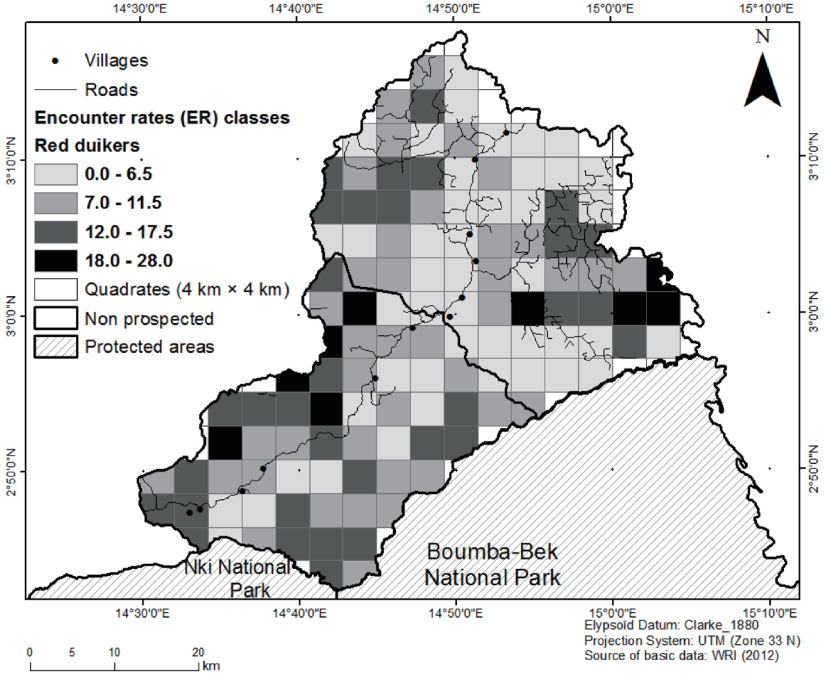


**Fig. 5.** Spatial distribution of signs of red duikers.

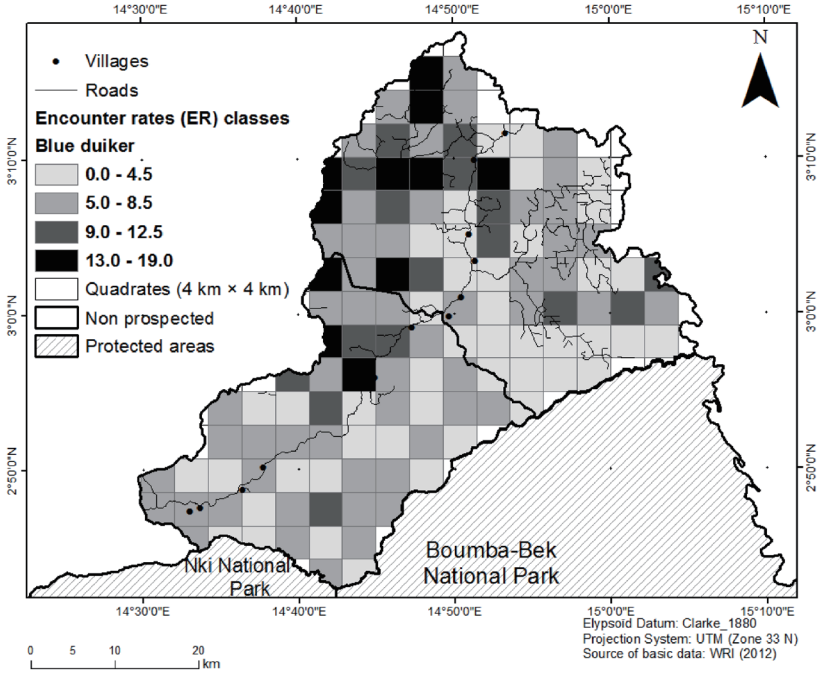


**Fig. 6.** Spatial distribution of signs of blue duiker.

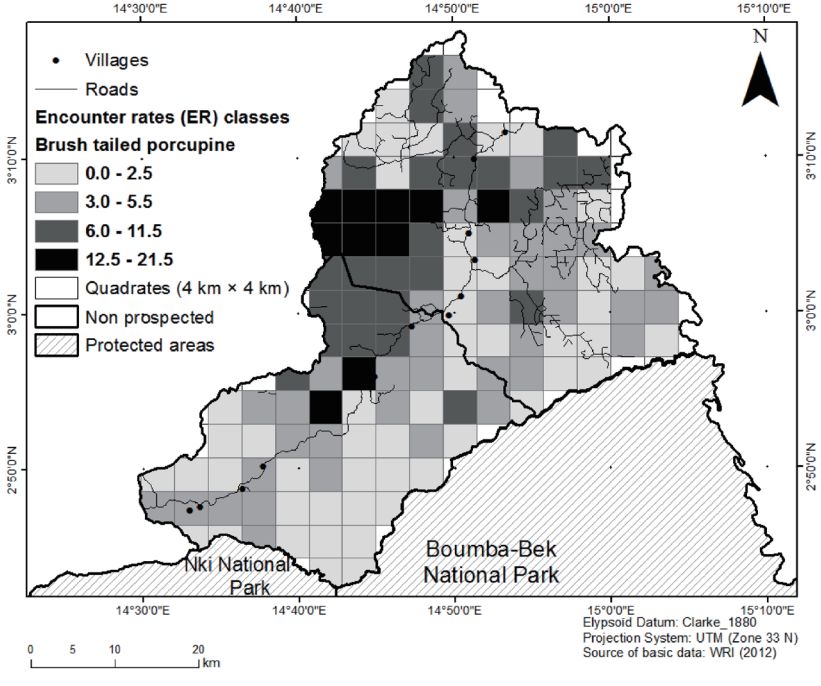


**Fig. 7.** Spatial distribution of signs of brush-tailed porcupine.

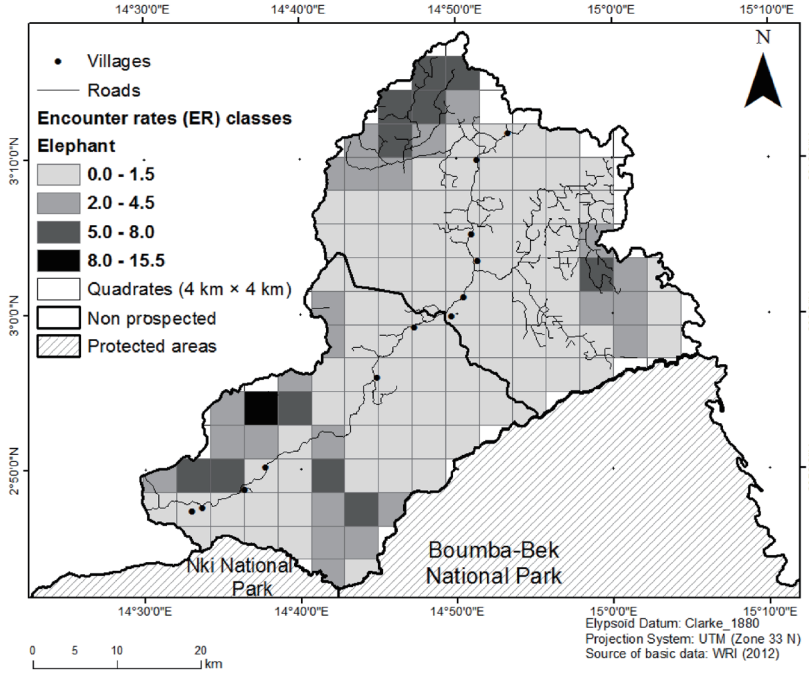


**Fig. 8.** Spatial distribution of signs of elephant.

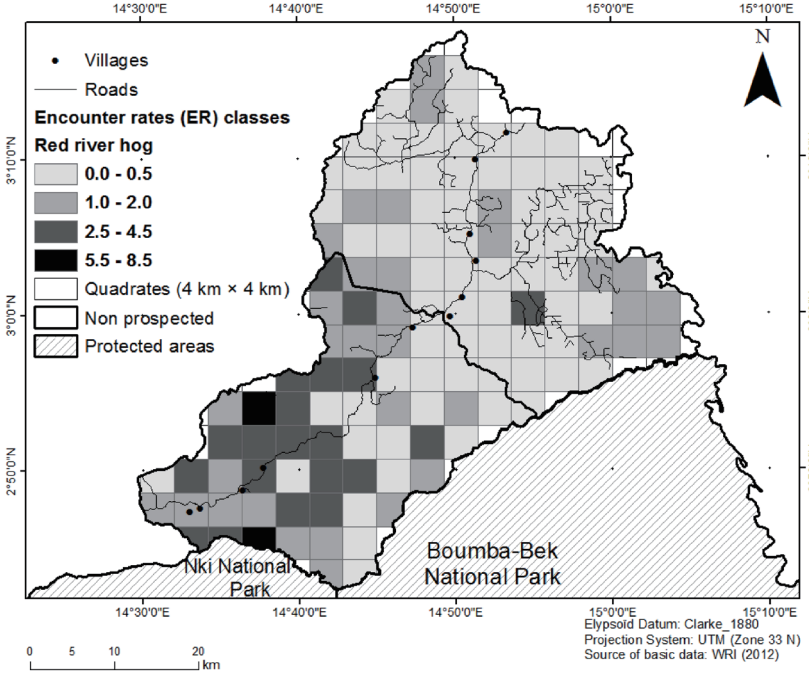


**Fig. 9.** Spatial distribution of signs of red river hog.

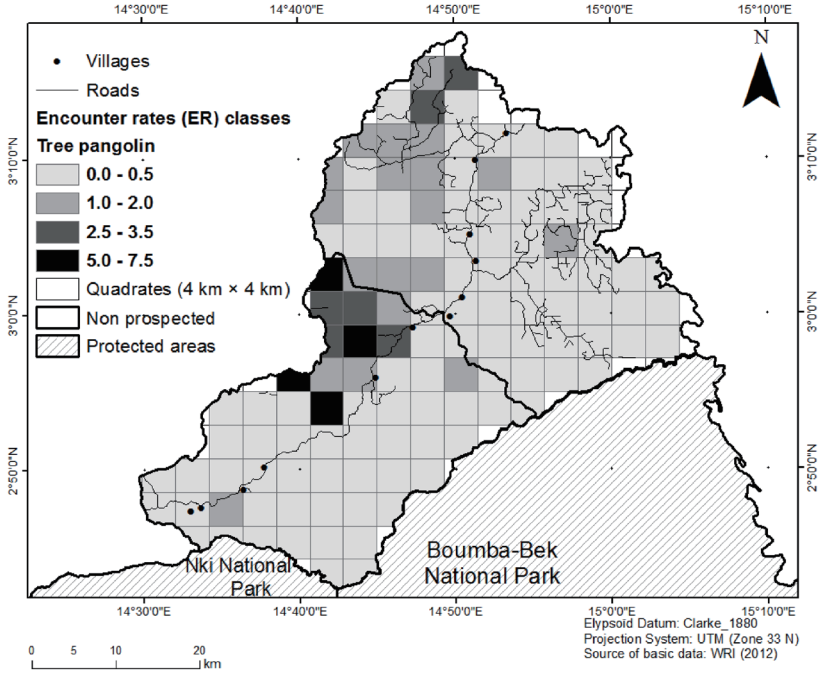


**Fig. 10.** Spatial distribution of signs of tree pangolin.

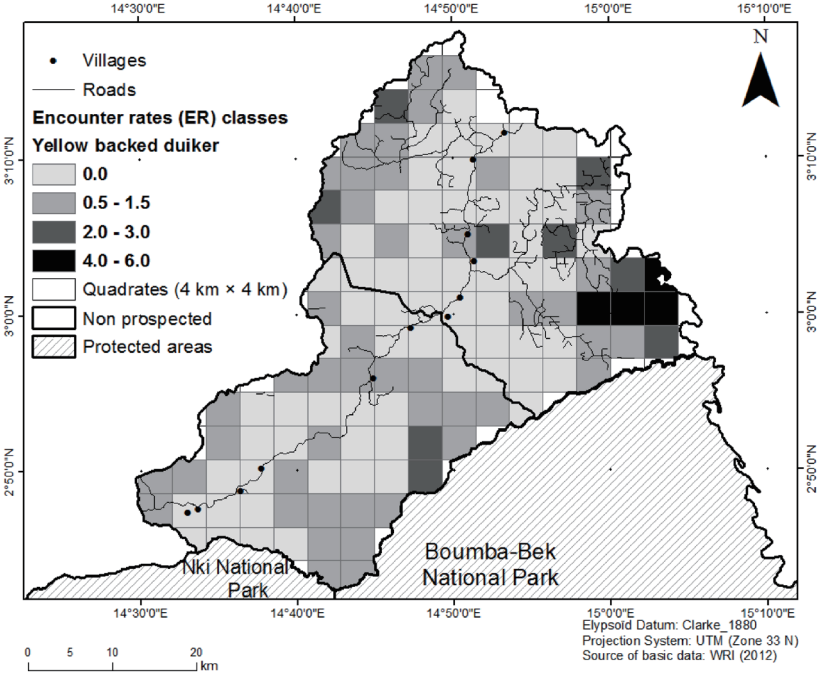


**Fig. 11.** Spatial distribution of signs of yellow-backed duiker.

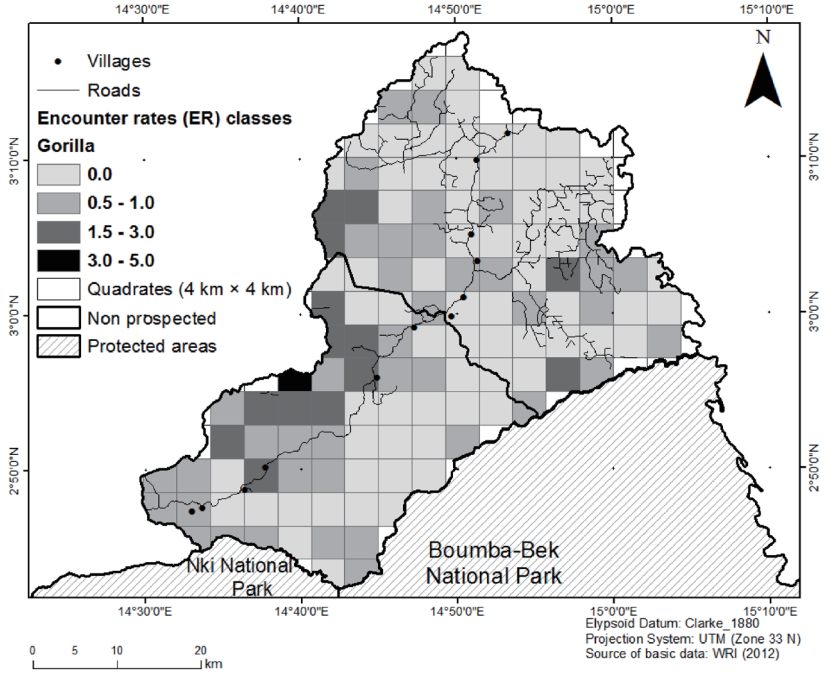


**Fig. 12.** Spatial distribution of signs of gorilla.

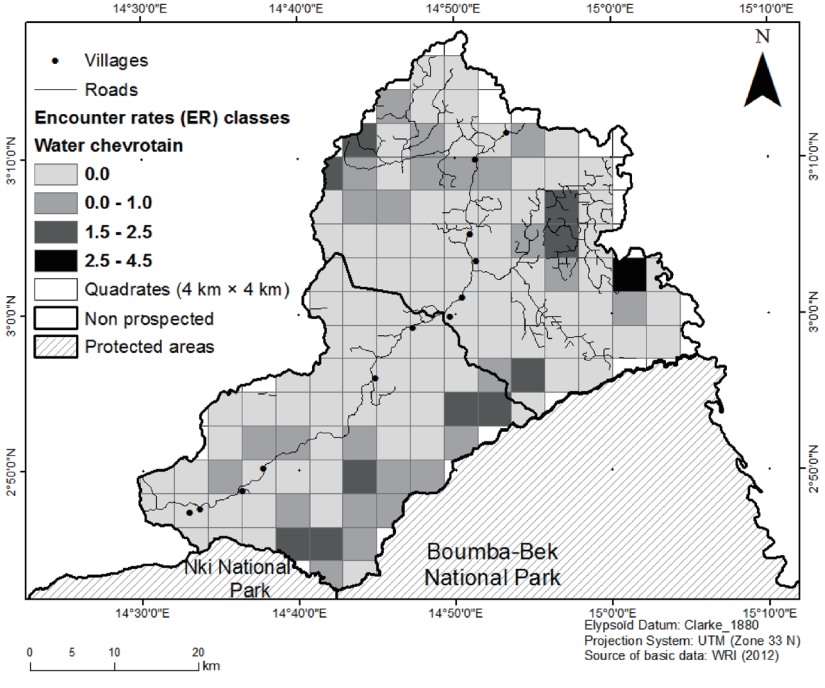


**Fig. 13.** Spatial distribution of signs of water chevrotain.

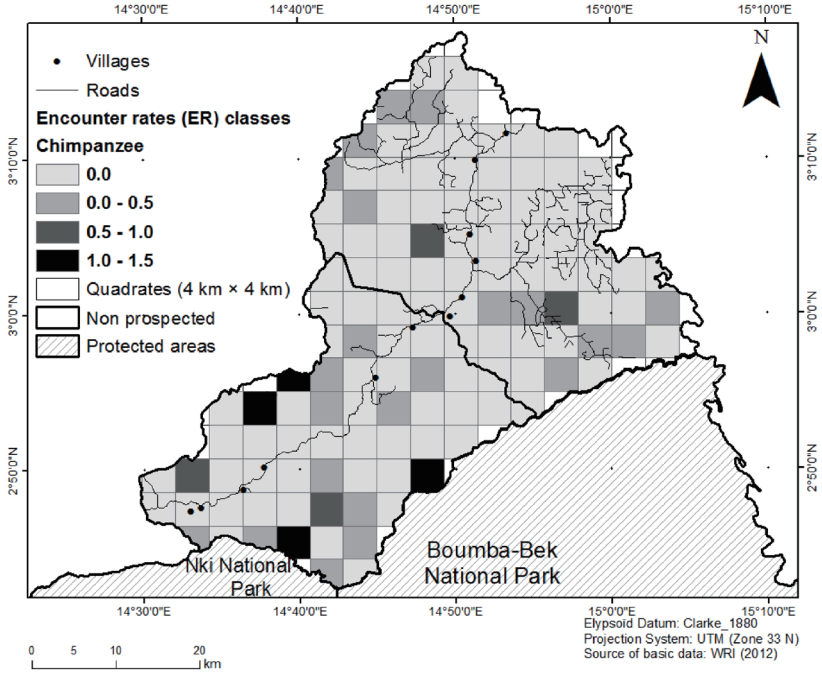


**Fig. 14.** Spatial distribution of signs of chimpanzee.

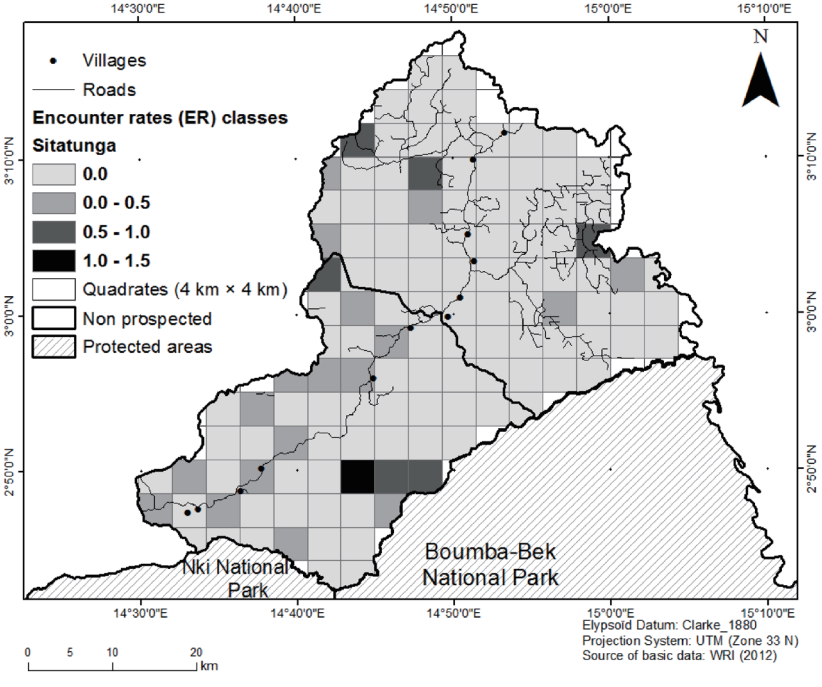


**Fig. 15.** Spatial distribution of signs of sitatunga.

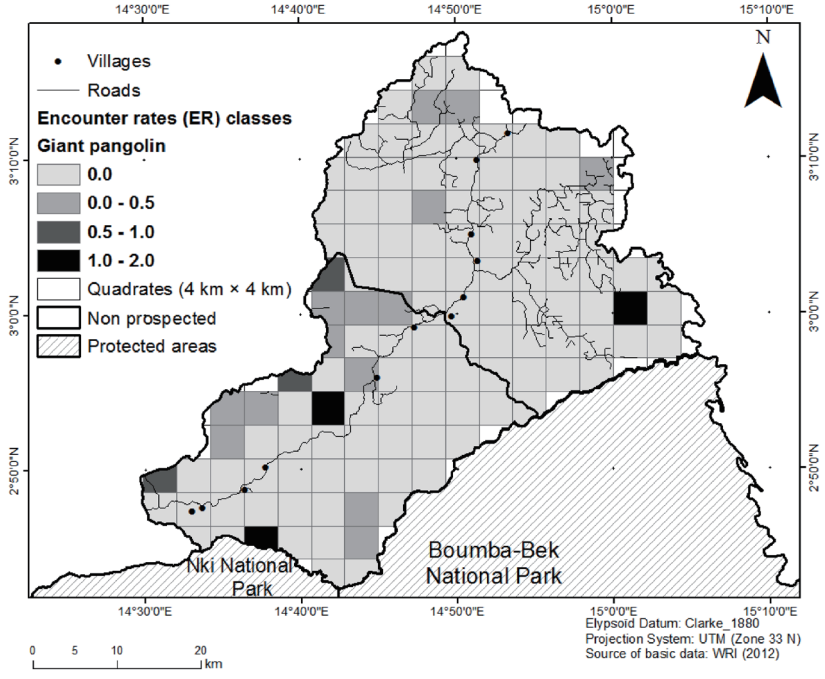


**Fig. 16.** Spatial distribution of signs of giant pangolin.

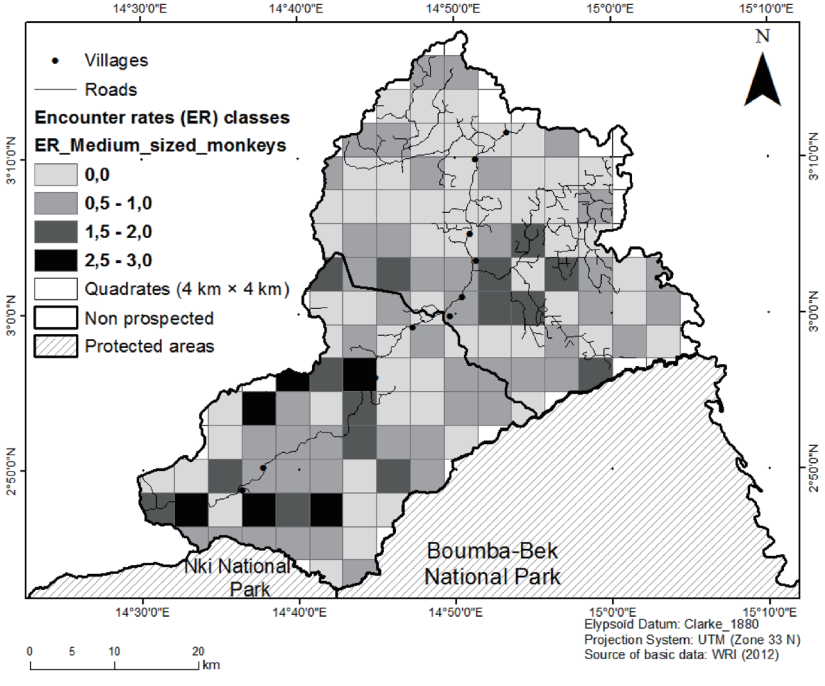


**Fig. 17.** Spatial distribution of signs of medium-sized monkeys.

**Table 2.** Densities of duikers, great apes, and elephant in CHZ 13

| Species | Number of dung or bed cluster counts on 70 transects | Dung or bed density (clusters/km$^2$) | Individual density (individuals/km$^2$) |
|---|---|---|---|
| Red duikers | 64 | 215.9 | 2.30 |
| Blue duiker | 37 | 143.4 | 1.60 |
| Gorilla | 11 | 9.7 | 0.29 |
| Yellow-backed duiker | 8 | 22.2 | 0.24 |
| Elephant | 89 | 293.8 | 0.13 |
| Chimpanzee | 13 | 1.9 | 0.03 |

**Table 3.** Densities of duikers, great apes, and elephant in CHZ 14

| Species | Number of dung or bed cluster counts on 56 transects | Dung or bed density (clusters/km$^2$) | Individual density (individuals/km$^2$) |
|---|---|---|---|
| Red duikers | 177 | 663.9 | 7.20 |
| Blue duiker | 118 | 431.3 | 4.90 |
| Gorilla | 23 | 24.5 | 0.74 |
| Yellow-backed duiker | 17 | 54.3 | 0.59 |
| Elephant | 104 | 310.4 | 0.14 |
| Chimpanzee | 20 | 3.6 | 0.06 |

transects in CHZ 13, and 17 dungs were recorded in CHZ 14. Estimated densities were 22.2 dungs/km² (CV = 56.0%) in CHZ 13 and 54.3 (CV = 36.2%) in CHZ 14. Using the defecation rate (4.4/day) and the dung degradation rate (21 days) determined by Koster & Hart (1988), densities were estimated at 0.24 individuals/km² in CHZ 13 and 0.59 in CHZ 14 (Tables 2 & 3). Because the CV for the dung density estimation was far above 30%, we calculated the density for the entire study area. The estimated density was 43.9 dungs/km² (CV = 30.6%), producing a density of 0.47 individuals/km².

(5) Elephant

A total of 89 elephant dungs were recorded along the transects in CHZ 13, and 104 dungs were recorded in CHZ 14. Densities were estimated at 293.8 dungs/km$^2$ (CV = 24.4%) in CHZ 13 and 310.5 (CV = 25.3%) in CHZ 14. Using the defecation rate (17.45/day) and dung degradation rate (0.0079) determined by Ekobo (1995) in Lobéké National Park in southeastern Cameroon, estimated densities were 0.13 individuals/km$^2$ in CHZ 13 and 0.14 in CHZ 14 (Tables 2 & 3).

(6) Chimpanzee

A total of 13 groups of chimpanzee beds were recorded along the transects in CHZ 13, and 20 in CHZ 14. Estimated densities were 1.88 groups of beds/km²

(CV = 44.2%) in CHZ 13 and 3.57 (CV = 34.1%) in CHZ 14. The average [±SE] number of beds per group was 1.44 ± 0.81. Using the bed production rate (0.842/day) from Plumtre & Reynolds (1996) and the bed degradation rate (106 days) from Tutin et al. (1995) at the Lopé (Gabon), densities were estimated at 0.03 individuals/km² in CHZ 13 and 0.06 in CHZ 14 (Tables 2 & 3). Because the CV for the dung density estimation was far above 30%, we calculated the density for the entire study area. The density of bed groups was estimated at 3.06 per km² (CV = 30.6%), producing a density of 0.05 individuals/km².

## DISCUSSION

The present study confirmed 31 large- and medium-sized mammal species, or groups of species, in the study area. This value is comparable to the 34 species reported previously in Boumba-Bek and Nki National Parks (Ekobo, 1998). Red duikers, blue duiker, and brush-tailed porcupine were the most abundant and widespread species. The presence of yellow-backed duiker was also observed; this species is very rare or even extinct in some nearby areas. Among primates, gorilla and chimpanzee were recorded, as well as several other monkey species, among which the putty-nosed guenon represented the most abundant species. In addition, we observed some swampy areas that are suitable for biodiversity conservation or ecotourism, as they were favorable sites for species such as elephant, sitatunga, and buffalo. CHZs 13 and 14 should therefore be of great interest for biodiversity conservation.

We also observed many signs of human activities during the field survey. Particularly in CHZ 13, the encounter rate of human activities (3.5 signs/km) was considerably higher than those for protected areas, whose ERs range between 0.1 and 1.2 (Ekobo, 1998; Nzooh Dongmo, 2003; Bene Bene & Nzooh Dongmo, 2005; Nzooh Dongmo et al., 2006). This higher level of human activity was likely observed because CHZ 13 contains thousands of inhabitants as well as the sawmills of logging companies. Increased human activities often cause forest deterioration, including overhunting, leading to declines in species richness and abundance (Fa et al., 2002; 2003; Waltert et al., 2005).

Based on Figs. 4–17, we observed three types of spatial distribution of the recorded mammals in accordance with relationships with the distribution of human activities: (1) Denser distributions in CHZ 14, where fewer human activities were observed. This type was typically represented by red river hog as well as red duikers, sitatunga, giant pangolin, and medium-sized monkeys. (2) No clear difference in density between the two CHZs, and rare observations along roadways. This type was typically represented by elephant, as well as yellow-backed duiker, water chevrotain, and chimpanzee. (3) Concentrated distributions from the northwestern part of CHZ 13 to the northern part of CHZ 14, where denser, although not the highest, human activities were recorded. This type was typically represented by brush-tailed porcupine, as well as blue duiker and tree pangolin. The distribution of gorillas could be classified as type

**Table 4.** Densities of duikers, great apes, and elephant in national parks and the study sites

| Site | Red duikers | Blue duiker | Gorilla | Yellow-backed duiker | Elephant | Chimpanzee |
|---|---|---|---|---|---|---|
| Lobéké National Park[1] | 11.0 | 3.1 | 1.6 | 1.2 | 1.0 | 0.5 |
| Boumba-Bek National Park[2] | 11.0 | 3.7 | 1.4 | 0.9 | 0.2 | 0.2 |
| Boumba-Bek National Park[3] | 11.2 | 10.6 | - | 2.7 | - | - |
| Nki National Park[2] | 6.0 | 0.1 | 0.6 | 1.7 | 0.5 | 0.2 |
| Nki National Park[4] | 6.8 | 2.8 | 3.1 | 1.1 | 0.8 | 0.4 |
| CHZ 13 (This study) | 2.3 | 1.6 | 0.3 | 0.2 | 0.1 | 0.0 |
| CHZ 14 (This study) | 7.2 | 4.9 | 0.7 | 0.6 | 0.1 | 0.1 |

[1]Nzooh Dongmo (2003), [2]Ekobo (1998), [3]Bene Bene & Nzooh Dongmo (2005), [4]Nzooh Dongmo et al. (2006).

(1), but it was rather an anomaly, in that the distribution of gorillas did not correspond well with the distribution of human activities.

Table 4 presents density estimations of duikers, great apes, and elephants in CHZs 13 and 14 as well as three national parks in southeastern Cameroon. The densities of red duikers, one of the most hunted game species in this area, were estimated to range between 6.0 and 11.2 individuals/km² in national parks. In CHZ 13, an area more densely populated by humans, the density was estimated at 2.3, which was much lower than the densities in national parks. In CHZ 14, the density was 7.2, which was comparable to the values in national parks. This result indicates that the population of red duikers in CHZ 13 has been affected, but not to depletion, whereas that in CHZ 14 has not largely decreased from the original state.

The densities of blue duiker, another frequently hunted game species, varied widely in national parks, between 0.1 and 10.6 individuals/km². The density of blue duiker in CHZ 13 was 1.6 individuals/km². If we exclude the estimation from Boumba-Bek National Park (Bene Bene & Nzooh Dongmo, 2005), which was much larger than the other estimations, the density in CHZ 13 was half of the value observed in national parks, whereas that observed in CHZ 14 was even higher than that in national parks. Based on the density estimations in CHZs 13 and 14, the population of blue duikers in CHZ 13 appears to have been affected due to hunting. However, as shown in Fig. 3, the ERs of blue duiker were observed more frequently in CHZ 13, likely because the proportions of recorded signs differed between the two sites: 37 dungs were recorded along 70 transects in CHZ 13, and 118 were found along 56 transects in CHZ 14. In contrast, 1,355 tracks/footprints were observed in CHZ 13, while only 831 were observed in CHZ 14. In any case, the density in CHZ 14 exceeded most values observed in national parks, indicating that human interventions have modified the local fauna and that the density of blue duiker has increased to some extent.

The densities of gorilla and yellow-backed duikers exhibited a pattern similar to that of red duikers. Their populations in CHZ 13 appeared to be more deteriorated than those in CHZ 14. The densities of gorillas in CHZ 14 were lower but were comparable to values in national parks. For elephants and chimpanzees, their densities in both CHZs 13 and 14 were considerably lower

than those in national parks. Thus, the distributions of these species appear to have been greatly affected by the presence of humans.

In conclusion, the impacts of human activities on the distribution of animals varied among the mammal species. Information is certainly still lacking, and research methods must be improved to achieve more precise density estimations. However, this variance must be kept in mind when designing effective wildlife management models that contribute not only to the conservation of biodiversity, but also to the sustainable use of bushmeat by local people.

ACKNOWLEDGEMENTS This study was conducted as part of the FOSAS Project supported by JST/JICA SATREPS and the Cameroonian Government. We are grateful to local communities and guides from the study area for their active participation in field surveys. The authors thank Dr. Hirokazu Yasuoka for his insightful comments to improve the quality of this paper.

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——— Accepted *March 10, 2014*

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